Gas Laws

Chapter 13

Warm Up!

- If you have a balloon filled with air and the temperature increased what would you observe?
- what happens to the gas particles inside the balloon?

- What would happen if the temperature was decreased?

Today's Agenda

- QOTD: What are the variables involved in the behavior of gases and what are the laws that govern gas behavior?

- Boyle's Law
- Charles' Law
- Gay-Lusacc's Law

Gas Laws

- We are considering 4 variables:
- V = volume n = moles
- T = temperature P = pressure

- Simulation: http://phet.colorado.edu/en/simulation/gas-properties

- We want to know if you change one variable, how does that affect the other measurements?

Relationships of P,V,T,n

- Remember that:

$$P = \frac{F}{A}$$

Volume related to area

Temperature and moles (n) related to force

Volume and pressure are INVERSELY related

Temperature and moles are DIRECTLY related to pressure

Gas Law's

- The individual gas laws assume that you hold all other variables that are NOT used **constant**!

- **Boyles Law** – Describes the inverse relationship between **volume** and pressure

- As volume decreases, pressure increases.

$$P_1V_1=P_2V_2$$

Using Boyle's Law

When conditions change, you solve for a new volume or pressure.

1. A balloon filled with gas at a pressure of 1.3 atm has a volume of 2.2 L. When the volume is increased to 4.1 L what is the new pressure?
2. What is the volume of a gas if 0.76 L of a gas is in a piston at 820 mmHg of pressure if the pressure is reduced to 610 mmHg?

Gas Laws

- **Charles' Law** - Describes the direct relationship between volume and temperature.

- As volume increases, temp increases!

- $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ is the same as $\frac{T_1}{V_1} = \frac{T_2}{V_2}$

Using Charles' Law

When conditions change, you solve for a new temperature or volume.

1. A balloon filled with gas has a volume of 2.2 L at 298K . When the balloon is heated to 355 K what is the new volume?
2. A gas mixture at 400K occupies a volume of 2.76 L. If the volume is decreased to 1.32 L what is the temperature?

Gas Laws

- **Gay-Lussac's Law** – Describes the direct relationship between temperature and pressure.

- As temperature increases, pressure increases.

- $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ is the same as $\frac{T_1}{P_1} = \frac{T_2}{P_2}$

Using Gay-Lussac's Law

When conditions change, you solve for a new temperature or pressure.

1. Gas particles are at standard pressure and temperature in a rigid container. When the container is heated at 373 K, what is the new pressure?
2. What is the temperature of a gas in a sealed rigid container at 268 kPa, if initially it was at a temperature of 200 K and a pressure of 85 kPa.

Gas Laws

- Combined Gas Law – relates pressure, temperature and volume and assumes moles is held constant.

- All the relationships in one tidy law!

- $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ is the same as $\frac{T_1}{P_1V_1} = \frac{T_2}{P_2V_2}$

Combined Gas Law

When conditions change, you solve for a new pressure, temperature, or volume!

1. A 350 mL sample of helium gas is collected at 22.0 ^{o}C and 99.3 kPa. What volume would this gas occupy at STP?
2. Initially a gas is at a pressure of 12 atm, a volume of 23 liters, and a temperature of 200 K. The pressure is raised to 14 atm and temperature increased to 300 K, what is the new volume of the gas?

Warm Up!

- A gas has a final volume of 22.4 L at STP. What was the initial volume measured at 810 mmHg and 200 K?

- What is the missing variable in the combined gas law?

- Considering P= F/A, where would this last variable belong if added to the combined gas law?

Todays Agenda

- QOTD: What is the ideal gas constant and how is it calculated?

- Avogadros Principle
- Ideal gas constant and law
- Calculating density and molar masses

- Lab Books Due **Thurs pm** (Baking Soda Lab)!
- All bookwork and Gas Law Packet **due Friday**

Combined Gas Law

- Combined Gas Law – relates pressure, temperature and volume and assumes moles is held constant.
- $P = \frac{F}{A}$ F related to T A related to V Where does moles fit?
- $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ is the same as $\frac{T_1}{P_1V_1} = \frac{T_2}{P_2V_2}$

Warm Up!

- At 298K, 2.43 L of gas has a pressure of 0.87 atm. If the temperature increases to 404 K and the pressure increases to 1.05 atm, what is the volume?

- At 295 K a 2 L tank has a pressure of 775 mmHg. In that same tank if the pressure increases to 1.06 atm, what is the temperature?

Today's Agenda

- QOTD: What is the ideal gas law and how can you calculate density and molar mass of a gas?

- Ideal gas law
- Density and mass derivations
- Practice Problems

The missing variable – n!

Avogadro's Principle - Equal volumes of gases contain the SAME number of particles

- Molar volume of a gas – volume that 1 mol occupies at STP (273K and 1 atm)

- What is that volume??? 22.4 L

Ideal Gas Constant

- Combined Gas law, plug in values from warm up and see if both sides are equal…

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \rightarrow$$ 0.0821 = 0.0821

- For a specific sample of gas – relationship between pressure, volume, and temp is ALWAYS the same $\frac{PV}{T}$ = **R = .0821 L atm/mol K**

Deriving the Ideal Gas Law

- Use the combined gas law and **R**, add in **moles** and…..

$$\frac{PV}{nT} = R \qquad \text{rearranges to} \qquad PV = nRT$$

In class practice:

Calculate the number of moles of ammonia gas (NH_3) contained in a 3.0 L vessel at 300 K and 1.50 atm of pressure.

Practice

- Determine the temperature of 2.49 mol of a gas contained in a 1.0 L vessel at 143 kPa.

- What is the pressure of a 0.75 mol of a gas at 303 K in a 3 L tank?

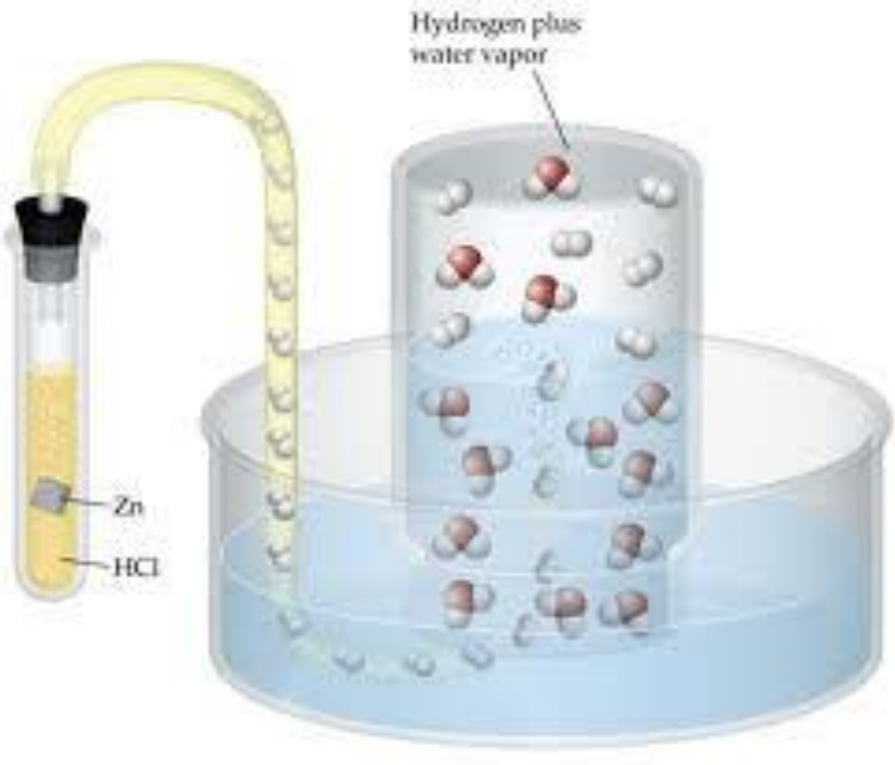
Measuring Gases over Water

The product of a reaction is a gas and it is collected in a beaker by displacing water. BUT…

$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

The gas collected will be a mixture of water vapor ($H_2O_{(g)}$) and H_2 gas.

You can use Dalton's law to find the partial pressure of H_2! $P_{total} = P_{gas} + P_{H2O}$



Example

- Hydrogen gas is collected over water at 22 ^{o}C in a 0.10 L beaker. The atmospheric pressure that day is 760 mmHg, how many moles of gas are collected?

Challenge Problem

- A 2.5 g sample of NH_3 decomposes into N_2 and H_2 gases. A total of 5.6 L are collected over water at 295 K. What is the total pressure of gas collected?